U. S. DEPARTMENT OF AGRICULTURE.

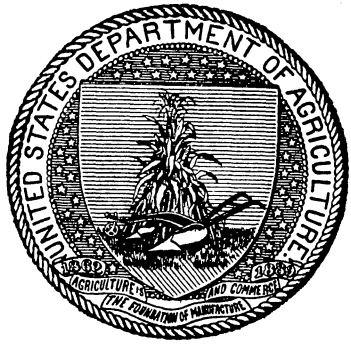
FARMERS' BULLETIN No. 269.

INDUSTRIAL ALCOHOL:

USES AND STATISTICS.

BY

H. W. WILEY,
CHIEF, BUREAU OF CHEMISTRY.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., October 1, 1906.

SIR: I beg to submit for publication a statement as to the uses of industrial alcohol, especially such as are of direct interest to the farmer, and some statistics relating thereto which are of value as showing the possibilities in the development of this industry. I recommend that this report be published as Farmers' Bulletin No. 269; in Farmers' Bulletin No. 268 will be found a description of the sources from which industrial alcohol can be made and the methods of manufacture. Certain text figures in the present bulletin are reproduced from drawings made from illustrations in several publications, namely: Die Verwertung des Spiritus für technische Zwecke; Scientific American Supplement, October 25, 1902; and Spiritus-kraftwagen für den landwirtschaftlichen Betrieb, to which this acknowledgment is due.

Respectfully,

H. W. WILEY,
Chief, Bureau of Chemistry.

Hon. JAMES WILSON,
Secretary of Agriculture.

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INDUSTRIAL ALCOHOL: USES AND STATISTICS.

INTRODUCTION.

It is important that the farmer should have a general idea of the uses to which industrial alcohol (usually denatured) may be devoted. While this information is not necessary for the production of the raw materials, it is nevertheless valuable in indicating the particular lines of industrial development which may be promoted by free alcohol in the arts as related to the welfare of agriculture. The technical uses of alcohol are extremely numerous, and no attempt will be made to give them all, but only to mention those which are of the greatest importance.

HEATING AND ILLUMINATION.

The most important of the uses of industrial alcohol as far as the farmer is directly concerned are those included in heating and illumination. For these purposes the farmers of the country, when the processes are adjusted and the technical difficulties of production, manufacturing, and denaturing are overcome, will find alcohol extremely useful. Especially will this be true in localities remote from centers of the production of wood, coal, kerosene, gasoline, natural gas, and oil, which now are the chief heating and illuminating agents.

ALCOHOL STOVES.

The success of the alcohol stove depends largely upon the character of the wick, which must absorb the alcohol and be so adjusted as to give the necessary heating surface. By converting the alcohol into a gas and burning the vapor thus formed the wick may be dispensed with and a more effective burner obtained. The general principles involved in heating with alcohol are the same as for other heating substances. The only differences are in the methods of producing the combustion. Alcohol burns with a pale blue flame which is intensely hot. It is without smoke, and if there be any odor at all it is an agreeable and not a disagreeable one. The products of combustion of pure alcohol are water and carbon dioxid. The latter gas should be conducted out of the room by the ordinary methods of

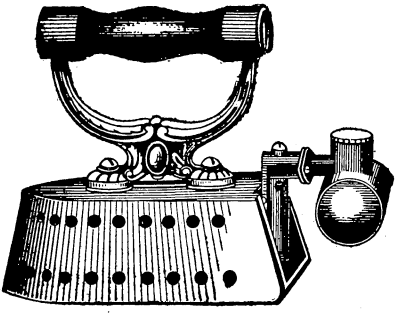

FIG. 1.—Alcohol burner for heating a flatiron.

ventilation. No form of burner should be allowed to pour the products of combustion into the room. The water which is formed is harmless, but the carbon dioxid, which is produced in large proportions, will soon vitiate the air of the room and tend to produce drowsiness, headache, and injury to health. The common methods of burning gas and kerosene in a room without ventilation are also objectionable for the same reason. Some form of ventilation by means of which the products of combustion in such cases could be removed from the room thru a chimney or otherwise is highly desirable.

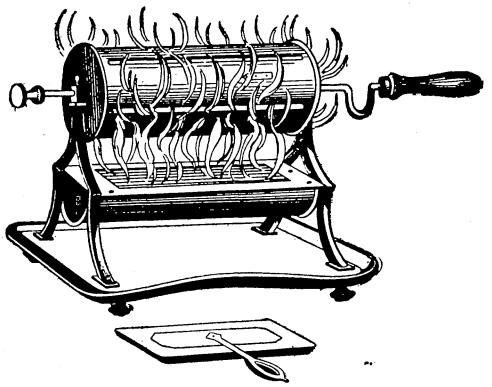

FIG. 2.—Alcohol burner for roasting coffee.

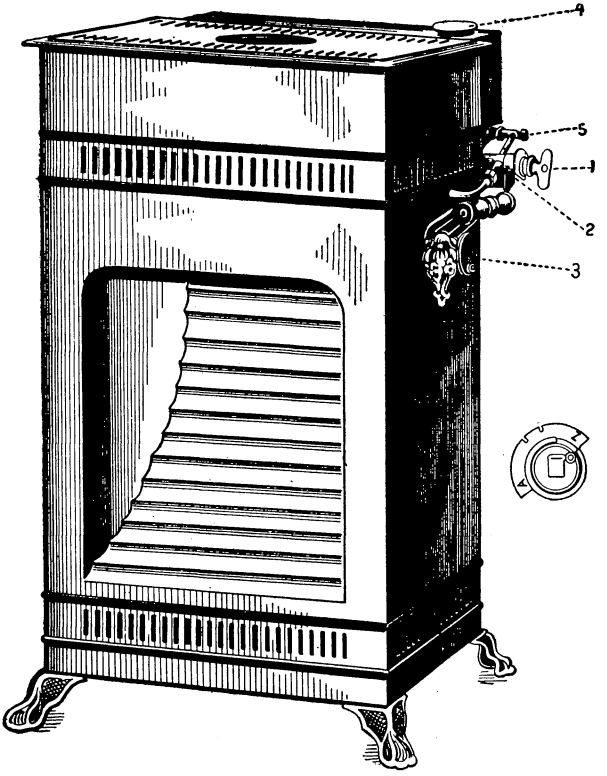

FIG. 3.—A small alcohol stove for heating purposes.

Stoves of many different kinds have been invented for burning alcohol. There are stoves for heating flatirons, soldering irons,

crimping irons, roasting coffee, etc. A smoothing iron which is designed to be heated by alcohol is shown in fig. 1, and a convenient roaster for coffee or peanuts in fig. 2.

A stove suitable for heating purposes, except that it has no chimney for carrying off the products of combustion, is pictured in fig. 3. In this figure No. 1 is the principal cock to control the admission of the gasified alcohol. No. 2 is the stopcock connecting with the heating apparatus for vaporizing the alcohol which is concealed in the mechanism of the stove. No. 3 is the stopcock for admitting a sufficient quantity of fresh alcohol before starting the stove to vaporize the alcohol for burning purposes. It is used only at the time of starting the fire, after which it is closed. No. 4 is the opening thru which the alcohol holder, which is just seen back of the stove, is filled. No. 5 is a stopcock for drawing off any remaining spirit in the holder when it is desirable to have it empty. The small figure marked *A Z* shows a

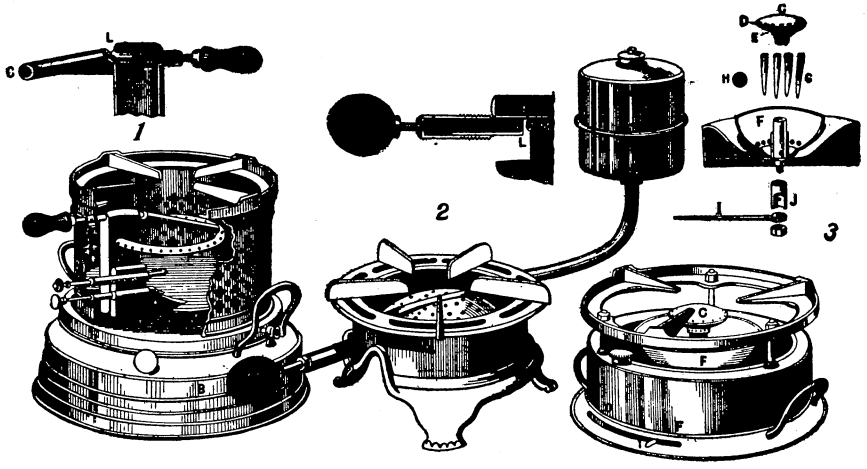

FIG. 4.—Three varieties of alcohol heaters.

device attached to the apparatus, which makes it impossible to connect the alcohol gas-forming apparatus and the stove until everything is in readiness. This is a kind of time lock upon the key, which prevents the opening or closing of the stopcocks at inopportune moments, and thus makes it impossible to flood the stove with alcohol and cause an explosion. The fluted arrangement in the front of the stove is for the purpose of reflecting the heat of the burning alcohol so as to throw it out in the largest possible quantities into the room. This is only one of the types of stove which may be used for heating purposes.

Another form of stove is shown in fig. 4, No. 1. In this stove the vaporizer is supplied by wicks *P* which draw up the alcohol from the reservoir in the bottom. A small wick (lower button at the left) serves to set the apparatus in operation by first heating the vaporizing kiln. This wick is afterwards extinguished and concealed in a

sheet which is closed by a horizontal flap (upper button). An ejector-valve *L*, represented in the upper part of the diagram, regulates the discharge of the circular burner *C*. Below the latter a white enameled disk of iron plate serves as a heat reflector. Nos. 2 and 3 are other forms of stoves which do not need any particular description.

Another form of stove is shown in fig. 5. This is a stove supplied by three circular burners, which are shown in the cross-section drawing. A double circulation of the products of combustion causes them to become separated and pass off thru a stovepipe at a relatively low temperature after having heated the air of the room as well as the vaporizer placed in the upper part of the apparatus.

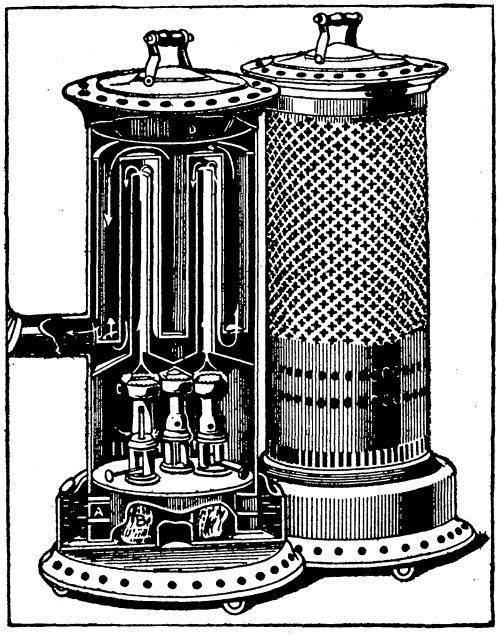

FIG. 5.—Alcohol stove with three circular burners.

ALCOHOL LAMPS.

Alcohol, as will be seen from the previous discussion respecting the alcohol stove, can not be used directly for illuminating purposes. The flame does not possess any notable illuminating power. In order that alcohol may be used for illumination it must be burned in a state of gas and the heat produced by the combustion utilized to produce incandescence in the ordinary mantle which surrounds the common gas flame for the same purpose. It has been discovered that when certain earths, such as thoria, in a state of fine subdivision, are subjected to the action of a high temperature, they become intensely white and produce by their incandescence the maximum degree of

illumination. The thoria is first deposited upon some substance such as cloth and so distributed that when the cloth burns away the particles of thoria remain in the original shape of the mantle. When held over the flame of gas or alcohol the particles become incandescent. To adjust an alcohol lamp for this purpose it is only necessary to make an attachment whereby the alcohol is first converted into a vapor. In order to light such a lamp a portion of the alcohol must first be vaporized.

In fig. 6 is shown an alcohol lamp, which is the property of the Bureau of Chemistry. The illustration shows very plainly the external mechanism of the lamp. The knob on the right is the handle of the pump, which brings a little of the alcohol around the wick holder delivering the alcohol to the vaporizing chamber. This handle is prest down two or three times by the thumb, rising by means of a spring to its original position. A few drops of alcohol are pumped up and are ignited by holding a match to the opening at the handle or above. The alcohol burns with a colorless flame for from thirty to sixty seconds. By this time the chamber is hot enough to volatilize the alcohol brought up by the wick. The mill-head on the left is then opened and the match applied at the top of the chimney, when the alcohol vapor ignites in the same manner as gas and soon heats the thorium mantle, shown inside of the chimney, to a white heat. The lamp then burns regularly without any further attention as long as any alcohol remains in the bowl.

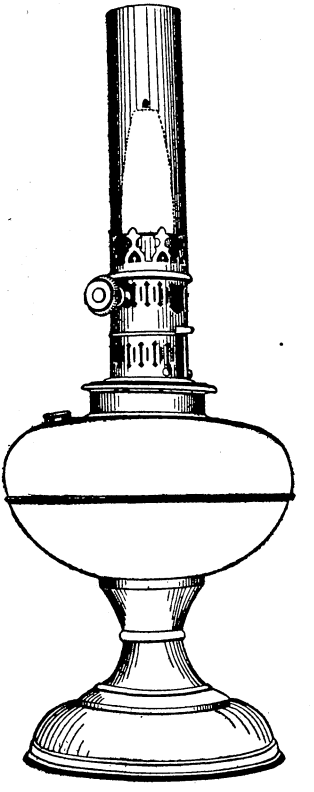

FIG. 6.—Alcohol lamp with pump attachment.

In fig. 7 are shown two views of another lamp, the principle of which is only slightly different from that just described. The lamp on the left is cut away in order to show the internal mechanism. The alcohol is fed by the wicks *D* to the copper vaporizer *A* placed under the mantle. The burner *C* is supplied by a Bunsen burner *B* placed beneath it and having its output regulated by means of a needle valve attached to the regulator button *E*. A small lateral aperture *F* permits of the introduction of a ball of asbestos saturated with alcohol for starting the vaporization at the moment of lighting.

In this lamp it is noticed that the small pump for lifting the alcohol to start the vaporization is omitted, its place being taken by the ball of asbestos saturated with alcohol, inserted at the opening *F* as just stated.

It is evident that the amount of heat produced is to some extent a measure of the illuminating value when the incandescent mantle is taken into consideration. It is the high temperature which produces the incandescence and therefore the gas which in burning gives the highest temperature, other conditions being the same,

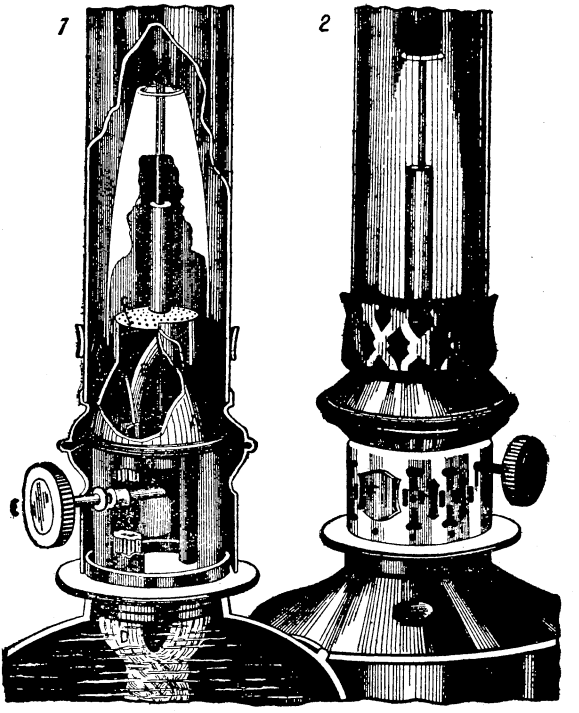

FIG. 7.—Alcohol lamp with asbestos primer.

would be of the most value for illumination. All of these points must be considered to prevent the formation of wrong opinions concerning the efficiency of alcohol for illumination, heating, and motive power, as compared with gasolene, which is the agent most used for these purposes, and which alcohol is expected to supersede.

QUANTITY OF HEAT YIELDED IN THE COMBUSTION OF ALCOHOL.

It has been estimated that 1 gram[a] of gasolene will yield on complete combustion 11,000 calories,[b] and 1 gram of pure alcohol 7,200 calories. No determination of the heat of combustion of ordinary

[a] 1 gram = 0.03527 ounce, or 15 grains.

[b] A calorie is the amount of heat necessary to raise 1 gram of water 1° centigrade (1.8° Fahrenheit).

commercial gasolene of the grade commonly used for fuel is found. Products of that nature appear to yield from 9,700 to 11,000 calories. In so far as heating purposes are concerned, therefore, it is evident that gasolene, weight for weight, is more valuable than alcohol.

ALCOHOL MOTORS.

It is quite certain that the use of alcohol motors on the farm will become quite common as soon as the technique of construction is practically complete and the price of alcohol is sufficiently low. Alcohol can be used for all purposes for which gasolene is employed, namely, the driving of wagons, carriages, stationary motors, water

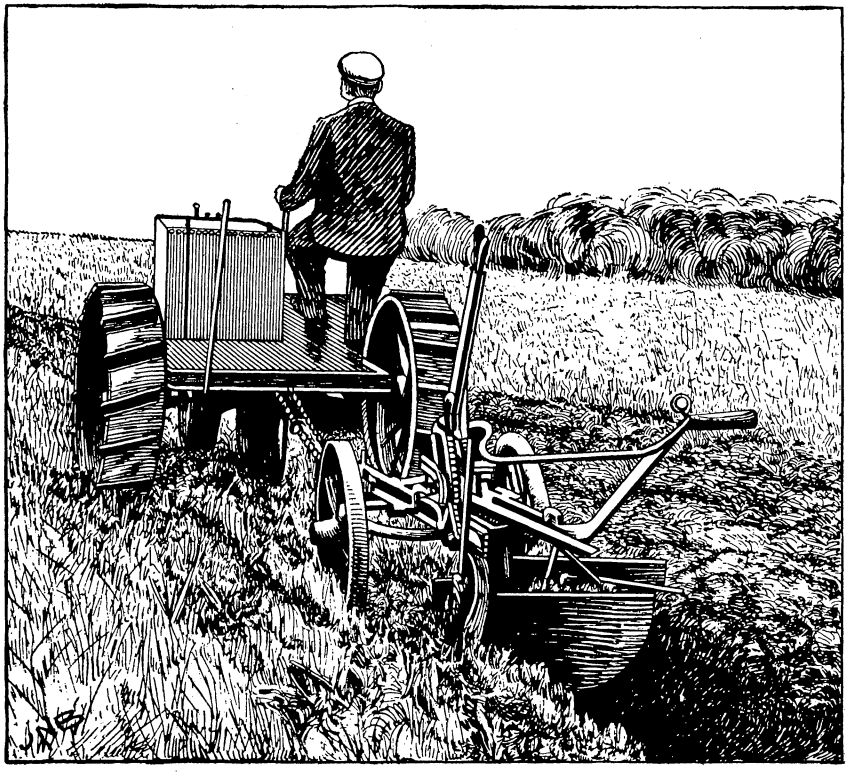

FIG. 8.—Adaptation of an alcohol motor for plowing.

pumps, mowing machines, plows, etc. Very little change need be made in the engine of a motor car designed to use gasolene to fit it for the use of alcohol. Gasolene becomes volatile at a temperature of blood heat (98.5° F.), while a much greater degree of heat (158° to 176° F.) is necessary to volatilize alcohol rapidly enough for motor purposes. This fact makes necessary a change in the explosion chamber of the engine when alcohol is to be used. This adjustment is especially important in the starting of the machine, as after it is in action the

temperature of combustion is quite sufficient to easily produce the gasification necessary.

Fig. 8 represents an ordinary plow suitable for attaching to a heavy motor apparatus driven by alcohol; fig. 9, a mowing machine, and fig. 10, a reaping and binding machine, both driven by alcohol motors. In regard to these heavy machines it may be said that they probably would come into use only on large farms where the surface of the soil is practically level. They would not be suitable for small farms nor those in hilly sections. In this connection attention is called to the fact that steam plowing, altho practicable and profitable under certain conditions, has not been practised to any great extent in this country, in fact, not nearly so much as in England. It is not likely, therefore, that plowing and harvesting by alcohol motors will come into use very soon, altho the possibilities are worthy of the consideration of the thoughtful farmer. On the other hand, it seems probable

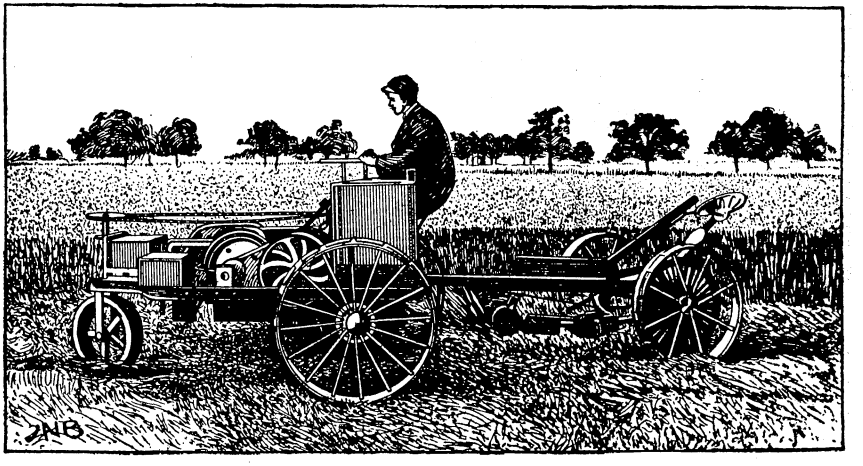

FIG. 9.—A mowing machine propelled by an alcohol motor.

that small motors for driving machines for chopping and grinding cattle food, pumping water, and similar purposes may be brought into very general use as soon as the denatured alcohol becomes cheap enough to render its use practicable.

In the driving of motor engines the quantity of heat evolved is not always a measure of efficiency. It is not the purpose of this bulletin to go into this subject at all, only to say that the vapor of alcohol can be more highly comprest at any given temperature without exploding than can the vapor of gasolene. As the decreased volume of the mixture of the explosive vapor and air is to a certain extent a measure of efficiency when engines are driven by the expansion of gases, the high degree of compressibility of the alcohol vapor without danger of explosion may compensate for the smaller quantity of heat which is generated by its combustion.

The problems connected with the use of alcohol for driving machinery are somewhat technical, and it is only desired to call attention to the possible advantages to the farmer from this source of power, and also to point out the difficulties which must be overcome. In this connection it seems that a word of caution is needed, as in the exploitation of tax-free alcohol extravagant opinions regarding its possibilities have been exprest. These exaggerated statements have been made without any intent to deceive or mislead, but on account of insufficient information. The natural tendency in all such matters is to select those points which are certain to be of great benefit and publish them broadcast, and to neglect the diffi-

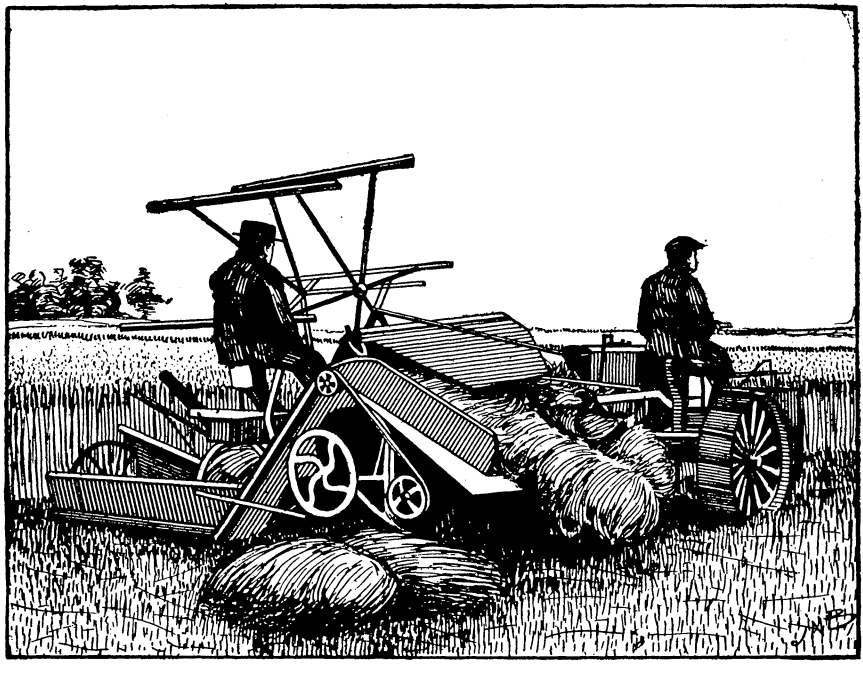

FIG. 10.—Adaptation of an alcohol motor to a reaper and binder.

culties and dangers which lie in the path of progress along these lines. Our farmers, who are naturally conservative, need very little caution in such matters, but it is important that a full understanding of the difficulties of these problems should be disseminated among the agricultural population. It is quite certain that if alcohol can be produced in the near future at a cost not exceeding 25 or 30 cents per gallon of 95 per cent strength, it will be a most valuable source of power on the farm. Altho with the present relative prices of alcohol and gasolene there is no financial advantage in the use of the former, it is highly probable that the price of gasolene will advance and that of alcohol fall. Thus the farmhouse and the

barn may be liberally supplied with water at such an elevation that it can be used with all the facility enjoyed by those who live in the city by means of a safe, cheap, and effective method of pumping made possible by the alcohol motor. The machinery around the barn and the stables which is utilized for chopping food and grinding grain in the preparation of rations for domesticated animals should be of a character which is efficient and at the same time without danger. An alcohol motor placed in a small room separated from the barn at such a distance as not to endanger it in case of an accident would make it possible to supply power of this kind. Altho alcohol is far less dangerous in use than gasolene as far as probability of explosion is concerned, there should be no misunderstanding respecting the fact that it is an explosive substance both when in the form of vapor and when mixt with air, and all the precautions which are used in the case of gasolene should be employed also with alcohol. While the use of these precautions will practically eliminate any source of danger, it is nevertheless advisable, even in the case of alcohol, to separate the building in which it is used from the barn, which contains more or less highly combustible matter. The fact that a substance is less dangerous than another is no excuse for omitting any of the precautions to prevent injury as the result of accident.

USES OF DENATURED ALCOHOL NOT DIRECTLY ENTERING INTO FARM OPERATIONS.

It seems advisable that some of the uses of industrial alcohol not directly connected with farm operations should be known to the farmer, in order that he may be fully informed respecting the industry in which he necessarily takes so important a part. The purposes for which tax-free alcohol can be used in the arts are fully set forth in a public document entitled "Free Alcohol, Hearings before the Committee on Ways and Means, House of Representatives, Fifty-ninth Congress, first session, February-March, 1906." A very full discussion of the subject is also found in an English report entitled "Industrial Alcohol Committee, Minutes of Evidence Taken before the Departmental Committee on Industrial Alcohol, with Appendices. Presented to both Houses of Parliament by Command of His Majesty. Printed for His Majesty's Stationery Office by Wyman & Sons (Limited), Fetter Lane, London, E. C., 1905." The evidence submitted in the two reports mentioned contains practically all that is known concerning the uses of denatured alcohol. It is not intended here even to make a résumé of this evidence; only the most important industries which are benefited by tax-free alcohol can be mentioned.

COAL-TAR COLORS.

Alcohol is used very extensively in the manufacture of dyes and other by-products from coal tar. The utilization of coal tar is an industry which has been almost exclusively monopolized by Germany, owing, in the opinion of many, to the fact that the Germans early recognized the importance of using alcohol free of tax in such industries. Whether or not this is the case may be open to some question, but it appears probable that this industry can not be established and flourish in the United States without the advantage of untaxed alcohol.

SMOKELESS POWDER.

The manufacture of smokeless powder is one of the industries in which tax-free alcohol is of the highest importance. Smokeless powder consists essentially of cotton which is subjected to treatment with sulfuric and nitric acids, whereby a certain quantity of oxid of nitrogen is introduced into the cotton, altering its properties without changing its appearance. The cotton thus treated is entirely different in character from the natural product. It burns with great ease and, when confined, with explosive violence, giving off practically no smoke and but few noxious fumes; hence for these two reasons it is especially valuable. Before use it is necessary that it be dissolved or at least reduced to a homogeneous, pasty mass. For this purpose the solvents which are most employed are ether and alcohol. Ether itself, as will be seen further on, is one of the products made from alcohol, and hence alcohol becomes a dominant factor in the manufacture of smokeless powder. If smokeless powder must be made with alcohol on which the tax has been paid it can not be profitably distributed for perhaps less than $1.25 or even more per pound. If tax-free alcohol can be used the price can be reduced more than one-half. In the smokeless powder made for Government use under the present regulations the alcohol which is employed is allowed to be used free of tax under supervision and thus the Government secures the powder at a much lower rate than would otherwise be the case. This, however, makes no difference to the Government, since it might collect the tax on the alcohol and pay the larger price per pound without any loss whatever. For the private consumer of powders the case is quite different, as he is compelled to pay the higher price when tax-free alcohol can not be used.

VARNISHES, LACQUERS, ETC.

One of the most important technical uses of alcohol is in the manufacture of varnishes and lacquers, where the gums which are employed are necessarily dissolved in alcohol. This use of alcohol is extremely important and affects a great many industries.

ETHER.

The ether of commerce, sometimes called sulfuric ether, is manufactured exclusively from alcohol by the action of sulfuric acid and heat. This ether is used in a great many technical operations, since it is one of the best solvents known, especially for fats. It is also extensively used in surgery as an anesthetic. Under the present arrangements ether used for technical purposes can only be made from alcohol on which tax has been paid, and thus its price is phenomenally high. By the use of tax-free alcohol for making ether, this price would be proportionally reduced, and in some countries the law permits the use of alcohol denatured by a special formula for this purpose. The denaturation of alcohol by the general process prescribed by the Commissioner of Internal Revenue[a] may unfit it for the manufacture of ether, even if such use were deemed admissible under the new law[b] and the regulations made in conformity therewith.

MEDICINES AND PHARMACEUTICAL PREPARATIONS.

Alcohol is used very extensively in the preparation of medicines. That great body of remedies known as tinctures is made by using alcohol as a solvent for the active principle of the herbs and plants from which the tinctures are made. The law, however, does not permit the use of denatured alcohol for "liquid medicinal purposes," and, concerning preparations which are used both in pharmaceutical preparations and in the arts, it is to be noted that under section 80 of the Regulations the Commissioner of Internal Revenue will consider all formulas submitted for the special denaturing of alcohol for technical purposes and will determine whether their use is consistent with the proper safeguarding of the revenue. The regulation states further: "But one special denaturant will be authorized for the same class of industries, unless it shall be shown that there is good reason for additional special denaturants."

IMITATION SILK.

The substance which is known as imitation silk is really a production from cotton or other cellulose material which, in its finished state, resembles silk somewhat in luster. It is not silk, and hence

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[a] The formula for completely denaturing alcohol given by the regulations of the United States Internal Revenue is as follows: To 100 parts of ethyl alcohol add 10 parts of approved methyl alcohol and one-half of 1 part of approved benzin. Formulas for special denaturants for specific purposes are to be submitted by manufacturers to the Commissioner of Internal Revenue, who will announce from time to time what formulas may be used in the several classes of industries.

[b] For the text of the law permitting the use of denatured alcohol, tax-free, for industrial purposes, see Farmers' Bulletin 268, Industrial Alcohol, Sources and Manufacture.

not even artificial silk. It is a textile product which has the promise of a successful future and is therefore of interest not only to the manufacturer and the consumer but to the farmer who produces the cellulose. Imitation silk is in a measure the same substance as smokeless powder, except that after it is made the nitrogenous constituents are removed, so as to restore the finished product again to the condition of ordinary cotton, devoid of explosive properties. In the making of imitation silk a partial nitrification of the cotton is accomplished in much the same manner as in making smokeless powder. The partially nitrated cotton is then reduced to a paste by solution in alcohol, ether, or other solvent, and in this condition is forced thru small orifices, producing fine fibers of a silky luster. After these are produced the oxid of nitrogen is removed from them by a chemical process which does not interfere with their lustrous appearance. These fibers are then spun and woven as ordinary silk or cotton, producing fabrics which resemble in luster the natural silk. The utilization of tax-free alcohol would be a great stimulus to the advancement of industries of this class.

ARTIFICIAL VINEGAR.

Dilute alcohol, commonly known as low wines, can be utilized for the manufacture of vinegar. For this purpose the dilute alcohol is made to pass over the fresh shavings of beech wood. These beech shavings furnish the organisms which oxidize the alcohol into acetic acid, and after passing thru a series of vats containing these shavings the alcohol is converted into a dilute solution of acetic acid. During the process there is a considerable loss of alcohol by evaporation. It is estimated that only about 70 per cent of alcohol is finally recovered as vinegar. This material ought not to be called vinegar, as it is acetic acid pure and simple. It is colored and treated so as to resemble vinegar made from cider or wine or malt, and to this extent becomes an adulteration. This industry may be mentioned as one that would be promoted by the use of tax-free alcohol, altho it deserves little if any encouragement. Section 59 of the Regulations concerning denatured alcohol, however, especially names "manufacturers of vinegar by the vaporizing process" among the classes of persons who may not store denatured alcohol on their premises or make use of it.

FLAVORING EXTRACTS.

The flavoring extracts of commerce are made largely with alcohol as a solvent. This should be the purest possible alcohol, and since it can not possibly be denatured and still remain potable and attractive, the law would probably not apply under conditions of this kind.

USE OF UNDENATURED ALCOHOL FREE OF TAX.

Under laws other than the denatured alcohol law, alcohol may be withdrawn from the distillery warehouse free of tax for certain purposes. Among these may be mentioned its use by the United States Government, its use for scientific purposes under certain conditions, and its use in the manufacture of sugar from sorghum. During the year ended June 30, 1905, 2,112,830.9 gallons of spirits were withdrawn for these purposes. Details in regard to such withdrawals can be obtained from the Commissioner of Internal Revenue, whose annual report for the year ended on the date mentioned furnishes valuable information for those proposing to engage in any way in the distillation of alcohol.

Attention should also be called to the fact that large quantities of undenatured alcohol are manufactured in the United States on which no tax is paid. The principal sources of this alcohol are as follows:

HARD CIDER.

The natural conversion of sweet cider into hard cider by the ferments which it contains is a process in which large quantities of alcohol are produced and on which no tax is paid. The term alcohol when used alone does not apply to such products, but only to alcohol produced by distillation. As is well known, the sugar which is one of the principal constituents of fresh cider is mixt with yeasts which naturally attach to apples, so that when exposed without sterilization fermentation takes place, the sugar disappears, and alcohol is formed. If we assume that the average apple juice contains 12 per cent of fermentable matter, it is seen that about 6 per cent of alcohol may be developed in a hard cider. No tax is put upon this cider, nor is there any supervision on the part of the Commissioner of Internal Revenue in its production.

WINE.

In the manufacture of wine the natural yeasts which attach to the grapes produce in the exprest grape juice a fermentation by means of which the grape juice is converted into wine. This is a vast industry in many countries and a very important industry in the United States. The alcohol which is formed in this way pays no tax, nor does the manufacturer of ordinary wines conduct his business under the supervision of the Commissioner of Internal Revenue. What is true of the juices of the grape and the apple is true of other fruit juices. They may be all of them fermented and their sugar converted into alcohol without Government supervision and without paying any tax. But when the alcohol which is produced by the fermentation of fruit juices is subjected to distillation

it comes under the control of the Commissioner of Internal Revenue. The distillation of alcohol from waste products is conducted under special regulations authorized by law.

SWEET WINE.

Brandy and other distilled spirits made from grapes or their refuse may be used for fortifying sweet wines upon the payment of a nominal tax of 3 cents a gallon, as provided for by the following act of Congress, which indicates the character of the wines that may be fortified in this way:

AN ACT To amend existing laws relating to the fortification of pure sweet wines.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section forty-three of the Act entitled "An Act to reduce the revenue and equalize duties on imports, and for other purposes," approved October first, eighteen hundred and ninety, as amended by section sixty-eight of the Act of August twenty-seventh, eighteen hundred and ninety-four, be further amended, so as to read as follows:

SEC. 43. That the wine spirits mentioned in section forty-two of this Act is the product resulting from the distillation of fermented grape juice, to which water may have been added prior to, during, or after fermentation, for the sole purpose of facilitating the fermentation and economical distillation thereof, and shall be held to include the product from grapes or their residues, commonly known as grape brandy; and the pure sweet wine, which may be fortified free of tax, as provided in said section, is fermented grape juice only, and shall contain no other substance whatever introduced before, at the time of, or after fermentation, except as herein expressly provided; and such sweet wine shall contain not less than four per centum of saccharine matter, which saccharine strength may be determined by testing with Balling's saccharometer or must scale, such sweet wine, after the evaporation of the spirits contained therein, and restoring the sample tested to original volume by addition of water: *Provided,* That the addition of pure boiled or condensed grape must or pure crystallized cane or beet sugar or pure anhydrous sugar to the pure grape juice aforesaid, or the fermented product of such grape juice prior to the fortification provided by this Act for the sole purpose of perfecting sweet wines according to commercial standard, or the addition of water in such quantities only as may be necessary in the mechanical operation of grape conveyors, crushers, and pipes leading to fermenting tanks, shall not be excluded by the definition of pure sweet wine aforesaid: *Provided, however,* That the cane or beet sugar, or pure anhydrous sugar, or water, so used shall not in either case be in excess of ten per centum of the weight of the wine to be fortified under this Act: *And provided further,* That the addition of water herein authorized shall be under such regulations and limitations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may from time to time prescribe; but in no case shall such wines to which water has been added be eligible for fortification under the provisions of this Act where the same, after fermentation and before fortification, have an alcoholic strength of less than five per centum of their volume.

SEC. 2. That section forty-nine of the said Act, approved October first, eighteen hundred and ninety, be amended so as to read as follows:

SEC. 49. That wine spirits used in fortifying wines may be recovered from such wine only on the premises of a duly authorized grape-brandy distiller; and for the purpose of such recovery wine so fortified may be received as material on the premises of such a distiller, on a special permit of the collector of internal revenue in whose district the distillery is located; and the distiller will be held to pay the tax on a product from such wines as will include both the alcoholic strength therein produced by the fermentation of the grape juice and that obtained from the added distilled spirits, subject, however, to the provisions of section

thirty-three hundred and nine of the Revised Statutes of the United States, as amended by section six of the Act entitled "An Act to amend the laws relating to internal revenue," approved March first, eighteen hundred and seventy-nine; and such spirits so recovered may be used by such distiller to fortify wines as authorized by section forty-two of the aforesaid Act, approved October first, eighteen hundred and ninety.

SEC. 3. That the Commissioner of Internal Revenue is hereby authorized to assign at each winery where wines are to be fortified such number of gaugers or storekeeper gaugers, in the capacity of gaugers, for special duties as may be necessary for the proper supervision of the making and fortifying of such wines, and the compensation of such officers shall not exceed five dollars per diem while so assigned, together with their actual and necessary traveling expenses, and also a reasonable allowance for their board bills, to be fixed by the Commissioner of Internal Revenue, but not to exceed two dollars per day for said board bills; and to cover the expenses to the Government attending the making and fortification of such sweet wines there shall be levied and assessed against each maker of such wines, and collected monthly, a charge of three cents on each taxable gallon of brandy used by him in the fortification of such wines during the preceding month. That bonds hereafter given under the provisions of the aforesaid Act of October first, eighteen hundred and ninety, as amended, shall be conditioned for the payment of the tax on all brandy removed thereunder and not used and accounted for within the time and in the manner required by law and regulations, and for the payment of all charges herein imposed on the brandy so withdrawn and used; and the said bond shall contain such other conditions as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may by regulation prescribe.

SEC. 4. That where brandy to be used in the fortification of wine is distilled on premises adjacent to the winery premises the Commissioner of Internal Revenue may, in his discretion, authorize the erection on either of said premises of fermenting vats for material to be used either in the manufacture of such wines or the brandy to be used in the fortification thereof; and all such materials used or received on either of said premises shall be under the supervision of the officer assigned to such winery, and shall be accounted for at such times and in such manner as the Commissioner may direct.

SEC. 5. That the provisions of sections thirty-two hundred and twenty-one and thirty-two hundred and twenty-three of the Revised Statutes of the United States, as amended by an Act approved March first, eighteen hundred and seventy-nine, are hereby extended to grape brandy withdrawn for use in the fortification of sweet wines, and which, prior to such use, is accidentally destroyed by fire or other casualty while stored in the fortifying room on the winery premises.

SEC. 6. That any person who by any process recovers from wines fortified under the provisions of the aforesaid Act approved October first, eighteen hundred and ninety, or amendments thereto, any brandy or wine spirits used in the manufacture or fortification of said wine, otherwise than is provided for in said Act and its amendments, or who shall rectify, mix, or compound with other distilled spirits such fortified wines or grape brandy or wine spirits unlawfully recovered therefrom, shall, on conviction, be punished for each such offense by a fine of not less than two hundred dollars nor more than one thousand dollars. But the provisions of this section, and the provisions of section thirty-two hundred and forty-four of the Revised Statutes of the United States, as amended, relating to rectification, shall not be held to apply to the blending of pure sweet wines fortified under the provisions of the said Act of October first, eighteen hundred and ninety, or amendments thereto, where such wines are blended for the sole purpose of perfecting the same according to commercial standard.

The following table shows the extent of the operations under this law, the kinds of sweet wines so fortified including angelica, concord, malaga, muscatel, port, scuppernong, sherry, sweet catawba, and tokay:

TABLE I.—*Quantity of grape brandy withdrawn from distilleries and bonded warehouses free of tax, and quantity of wines so fortified, by districts, for the year ended June 30, 1905.*[a]

District.	Grape brandy used in fortification.	Total wines produced.	
		Before fortification.	After fortification.
	Gallons.	*Gallons.*	*Gallons.*
First California	2,661,912.5	9,179,258.47	10,716,649.78
Fourth California	598,509.5	2,083,992.13	2,444,548.65
First Missouri	272.4	873.48	1,024.06
First New Jersey	714.0	5,450.00	6,150.50
Twenty-eighth New York	131,438.7	447,113.07	522,757.84
Fourth North Carolina	2,308.7	36,049.00	37,747.00
Tenth Ohio	11,374.5	39,788.50	46,678.00
Second Virginia	24,289.3	200,029.48	214,500.00
Total	3,430,819.6	11,992,554.13	13,990,055.83

[a] Annual Report of the Commissioner of Internal Revenue, 1905, p. 131.

STATISTICS ON ALCOHOL PRODUCTION.

THE UNITED STATES.

To give an idea of the magnitude of the present industry in distilled spirits and the possibilities of its enlargement, the following statistical data are quoted from the report of the Commissioner of Internal Revenue for the fiscal year ended June 30, 1905:

TABLE II.—*Distilleries registered and operated during the year ended June 30, 1905.*

State or Territory.	Grain.		Molasses.		Fruit.		Total registered.	Total. operated.
	Registered.	Operated.	Registered.	Operated.	Registered.	Operated.		
Alabama	17	15	.....	.....	17	17	34	32
Arkansas	25	16	.....	.....	13	12	38	28
California	1	1	2	1	224	218	227	220
Colorado	2	2	.....	.....	1	1	3	3
Connecticut	3	3	.....	.....	28	23	31	26
Delaware	1	.....	.....	.....	10	10	11	10
Florida	.....	.....	.....	.....	1	1	1	1
Georgia	40	39	.....	.....	32	32	72	71
Idaho	.....	.....	.....	.....	3	3	3	3
Illinois	12	10	.....	.....	5	5	17	15
Indiana	22	11	.....	.....	17	16	39	27
Iowa	.....	.....	.....	.....	1	1	1	1
Kansas	.....	.....	.....	.....	1	.....	1	.....
Kentucky	257	223	1	1	30	29	288	253
Louisiana	1	.....	2	2	3	3	6	5
Maryland	30	25	.....	.....	10	8	40	33
Massachusetts	1	1	6	6	3	2	10	9
Michigan	.....	.....	1	1	.....	.....	1	1
Missouri	61	43	.....	.....	18	18	79	61
Nebraska	1	1	.....	.....	1	1	2	2
New Hampshire	1	.....	1	1	.....	.....	2	1
New Jersey	1	.....	.....	.....	36	34	37	34
New Mexico	.....	.....	.....	.....	3	3	3	3
New York	5	2	1	1	36	32	42	35
North Carolina	66	57	.....	.....	326	298	392	355
Ohio	29	23	.....	.....	30	26	59	49
Oklahoma	7	3	.....	.....	.....	.....	7	3
Oregon	.....	.....	.....	.....	5	5	5	5
Pennsylvania	100	83	.....	.....	9	8	109	91
Rhode Island	1	1	.....	.....	3	3	4	4
South Carolina	14	9	.....	.....	.....	.....	14	9
Tennessee	70	58	.....	.....	28	24	98	82
Texas	2	1	.....	.....	8	8	10	9
Utah	.....	.....	.....	.....	1	1	1	1
Virginia	111	89	.....	.....	198	182	309	271
Washington	2	.....	.....	.....	3	3	5	3
West Virginia	8	8	.....	.....	4	4	12	12
Wisconsin	5	4	.....	.....	.....	.....	5	4
Total	896	728	14	13	1,108	1,031	2,018	1,772

TABLE III.—*Quantities of grain and other materials used for the production of distilled spirits during the fiscal year ended June 30, 1905, by States and Territories.*

State or Territory.	Malt.	Wheat.	Barley.	Rye.	Corn.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Alabama	5,580	.....	28	3,443	30,978
Arkansas	1,627	.....	11	735	11,034
California	741	1,188	2,396	2,169	1,288
Colorado	20	.....	.....	66	171
Connecticut	10,834	.....	.....	20,106	17,266
Georgia	13,000	.....	.....	483	67,942
Illinois	1,112,069	.....	.....	315,912	8,053,364
Indiana	462,695	183	.....	119,321	3,959,267
Kentucky	888,279	5,373	3,920	1,206,595	4,670,252
Maryland	250,667	.....	.....	1,180,991	29,552
Massachusetts	2,093	.....	.....	6,329	5,885
Missouri	14,153	478	.....	24,810	59,670
Nebraska	47,327	.....	.....	13,801	334,687
New York	139,012	.....	.....	334,293	342,712
North Carolina	25,376	.....	.....	38,127	183,374
Ohio	288,879	3,858	.....	364,587	1,990,599
Oklahoma Territory	275	.....	.....	307	2,763
Pennsylvania	372,680	1,029	314	1,595,721	111,627
Rhode Island	231	.....	.....	445	410
South Carolina	18,453	.....	.....	24,918	113,323
Tennessee	37,206	58	232	28,735	249,523
Texas	17	.....	.....	.....	186
Virginia	12,989	314	.....	31,445	55,464
West Virginia	16,960	.....	.....	65,132	2,996
Wisconsin	77,415	.....	2,973	110,557	298,171
Total	3,798,578	12,481	9,874	5,489,028	20,592,504

State or Territory.	Oats.	Mill feed.	Molasses.	Other materials.	Total.	
	Bushels.	*Bushels.*	*Gallons.*	*Bushels.*	*Bushels.*	*Gallons.*
Alabama	.....	.....	.....	.....	40,029	.....
Arkansas	.....	.....	.....	.....	13,407	.....
California	.....	.....	1,378,957	.....	7,782	1,378,957
Colorado	.....	.....	.....	.....	257	.....
Connecticut	.....	.....	.....	.....	48,206	.....
Georgia	.....	.....	.....	.....	81,425	.....
Illinois	505	.....	.....	.....	9,481,850	.....
Indiana	2,787	.....	.....	.....	4,544,253	.....
Kentucky	2,489	21	219,996	.....	6,776,929	219,996
Louisiana	.....	.....	7,036,457	.....	.....	7,036,457
Maryland	1,414	.....	.....	.....	1,462,624	.....
Massachusetts	.....	.....	1,923,682	.....	14,307	1,923,682
Michigan	.....	.....	4,419,716	.....	.....	4,419,716
Missouri	.....	109	.....	.....	99,220	.....
Nebraska	.....	.....	.....	.....	395,815	.....
New Hampshire	.....	.....	18,225	.....	.....	18,225
New York	.....	.....	5,545,200	.....	816,017	5,545,200
North Carolina	.....	.....	.....	.....	246,877	.....
Ohio	11,763	200	.....	.....	2,659,826	.....
Oklahoma Territory	.....	.....	.....	.....	3,345	.....
Pennsylvania	.....	.....	7,320	.....	2,081,371	7,320
Rhode Island	.....	.....	.....	.....	1,086	.....
South Carolina	.....	.....	.....	.....	156,694	.....
Tennessee	.....	1,132	.....	.....	316,886	.....
Texas	.....	.....	.....	.....	203	.....
Virginia	.....	.....	.....	.....	100,212	.....
West Virginia	.....	.....	.....	.....	85,088	.....
Wisconsin	.....	.....	.....	4,500	493,616	.....
Total	18,898	1,462	20,549,553	4,500	29,927,325	20,549,553

The average yield per bushel of grain was $\frac{133,932,478}{29,927,325}$=4.47+ gallons of spirits.

The average yield per gallon of molasses used for the production of spirits was $\frac{12,086,329}{18,387,650}$=0.657+ gallon.

The average yield per gallon of molasses used for the production of rum was $\frac{1,791,987}{2,161,903}$=0.828+ gallon.

TABLE IV.—*Quantity of each kind of fruit brandy produced during the fiscal year ended June 30, 1905, by collection districts.*

District.	Apple.	Peach.	Grape.	Pear.	Apricot.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Alabama	2,609.8	702.6	7.0	.....	.....
Arkansas	26,531.0	725.5	66.0	.....	.....
First California	441.0	18,068.9	3,811,625.7	2,904.6	1,466.3
Fourth California	.....	.....	790,508.5	.....	1,758.8
Connecticut	17,812.6	.....	1,876.9	.....	.....
Florida	.....	.....	16.0	144.8	.....
Georgia	3,569.4	3,532.5	41.3	14.0	.....
Fifth Illinois	.....	.....	133.0	.....	.....
Eighth Illinois	.....	.....	183.2	.....	.....
Sixth Indiana	551.8	68.4	74.0	.....	.....
Seventh Indiana	68,507.1	30.0	.....	.....	.....
Fourth Iowa	.....	.....	28.5	.....	.....
Second Kentucky	12,376.1	.....	.....	.....	.....
Fifth Kentucky	86,745.7	.....	.....	.....	.....
Seventh Kentucky	732.0	.....	.....	.....	.....
Eighth Kentucky	810.9	.....	.....	.....	.....
Louisiana	.....	9.4	.....	.....	.....
Maryland	17,206.4	20,662.6	.....	5,019.5	.....
Third Massachusetts	2,135.8	.....	.....	.....	.....
First Missouri	886.2	966.3	7,408.1	.....	.....
Sixth Missouri	970.6	445.0	363.4	.....	.....
Montana	227.7	150.2	.....	.....	.....
Nebraska	15.4	.....	.....	.....	.....
First New Jersey	56,502.8	.....	285.0	.....	.....
Fifth New Jersey	56,850.3	86.6	2,291.1	.....	.....
New Mexico	25.0	.....	140.9	.....	.....
First New York	217.0	.....	1,713.6	.....	.....
Fourteenth New York	22,678.3	.....	.....	.....	.....
Twenty-first New York	133,501.0	.....	.....	.....	.....
Twenty-eighth New York	20,752.4	30.5	25,476.5	.....	.....
Fourth North Carolina	10,021.9	72.5	1,055.0	.....	.....
Fifth North Carolina	25,035.6	150.0	.....	.....	.....
First Ohio	1,713.1	.....	119.0	.....	.....
Tenth Ohio	8,959.9	1,498.7	72,371.3	.....	.....
Eleventh Ohio	433.0	.....	142.5	.....	.....
Eighteenth Ohio	1,052.6	.....	977.5	.....	.....
Oregon	116.6	17.0	.....	.....	.....
First Pennsylvania	15,646.3	.....	355.9	.....	.....
Second Tennessee	210.0	.....	.....	.....	.....
Fifth Tennessee	19,745.0	175.0	.....	.....	.....
Fourth Texas	.....	530.4	.....	.....	.....
Second Virginia	3,974.2	2.5	2,706.8	.....	.....
Sixth Virginia	11,251.6	340.0	463.5	.....	.....
Washington	218.2	129.5	.....	.....	.....
West Virginia	1,309.4	.....	.....	.....	.....
Total	632,343.7	48,394.1	4,720,430.2	8,082.9	3,225.1

TABLE IV.—*Quantity of each kind of fruit brandy produced during the fiscal year ended June 30, 1905, by collection districts*—Continued.

District.	Berry.	Prune.	Fig.	Cherry.	Total.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Alabama					3,319.4
Arkansas					27,322.5
First California		24,439.9			3,858,946.4
Fourth California		1,927.5			794,194.8
Colorado			61.8		61.8
Connecticut		214.3	201.5		20,105.3
Florida					160.8
Georgia					7,157.2
Fifth Illinois					133.0
Eighth Illinois					183.2
Sixth Indiana					694.2
Seventh Indiana					68,537.1
Fourth Iowa					28.5
Second Kentucky					12,376.1
Fifth Kentucky					86,745.7
Seventh Kentucky					732.0
Eighth Kentucky					810.9
Louisiana					9.4
Maryland					42,888.5
Third Massachusetts					2,135.8
First Missouri					9,260.6
Sixth Missouri		55.0		101.6	1,935.6
Montana		21.8			399.7
Nebraska					15.4
First New Jersey		1,782.2			58,570.0
Fifth New Jersey		284.2	146.5	20.5	59,679.2
New Mexico					165.9
First New York		1,486.2	305.6		3,722.4
Fourteenth New York					22,678.3
Twenty-first New York					133,501.0
Twenty-eighth New York	32.5				46,291.9
Fourth North Carolina	12.0				11,161.4
Fifth North Carolina					25,185.6
First Ohio					1,832.1
Tenth Ohio		2,456.0			85,285.9
Eleventh Ohio					575.5
Eighteenth Ohio	726.4				2,756.5
Oregon		421.9		15.0	570.5
First Pennsylvania		1,099.4			17,101.5
Second Tennessee					210.0
Fifth Tennessee					19,920.0
Fourth Texas					530.4
Second Virginia	95.0				6,778.5
Sixth Virginia				10.0	12,065.1
Washington		191.6			539.3
West Virginia					1,309.4
Total	865.9	34,380.0	715.4	147.1	5,448,584.4

TABLE V.—*Comparative statement of materials used and spirits produced during the last two fiscal years.*

Year.	Grain used.	Spirits produced from grain.	Molasses used to produce spirits.	Spirits produced from molasses.	Molasses used to produce rum.	Rum produced.	Total production.
	Bushels.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1904	27,687,683	123,549,427	16,425,853	8,961,346	2,123,553	1,801,179	134,311,952
1905	29,927,325	133,932,478	18,387,650	12,086,329	2,161,903	1,791,987	147,810,794

GREAT BRITAIN.

The new law relating to the denaturing of alcohol in England for industrial purposes went into effect on October 1, 1906. One of the principal objects of the law is to extend the uses of denatured alcohol to the manufacture of certain products which could not be made with the ordinary denatured alcohol as provided under the old law. Under the new order denatured alcohol may be used for the following additional purposes:

1. Methylated spirits may be used in the manufacture of sulfuric ether, ethyl chlorid, methyl chlorid, ethyl bromid, chloroform, and hydrate of chloral, for use as a medicine or in any art or manufacture; and no objection is made to the substitution of methylated spirits for rectified spirits in the preparation of soap, compound camphor, aconite, and belladona liniments of the British Pharmacopœia.

2. No methylated spirits nor any derivative thereof, except sulfuric ether, ethyl chlorid, methyl chlorid, ethyl bromid, chloroform, and hydrate of chloral, can lawfully be present in any article whatever capable of being used either wholly or partially as a beverage, or internally as a medicine.

Generally it may be said that in addition to the alterations in the law in regard to the mineralized spirit, the old "ordinary" spirit is to be replaced by a new kind officially designated "industrial methylated spirits." In other words, the mixture of 9 parts of 90 per cent rectified spirits and 1 part of crude methyl alcohol is replaced by a mixture in which the proportion of wood alcohol or other approved denaturing substance is reduced to a minimum of one-nineteenth of the bulk of the spirit denatured. The result of this is that such denatured alcohol becomes suitable for the manufacture of the substances mentioned above, thus greatly extending the industrial uses of the denatured spirits.

The mineralized methylated spirit, sold for lamps and domestic use generally, contains, in addition to the above, three-eighths of 1 per cent of approved mineral naphtha. The following statement gives an idea of the production of denatured alcohol in Great Britain:

TABLE VI.—*Denatured alcohol produced in Great Britain, 1900–1904.*[a]

Year.	Ordinary methylated spirit.	Mineralized methylated spirit.	Total.
	Gallons.	*Gallons.*	*Gallons.*
1900	2,058,450	1,328,162	3,386,612
1901	2,075,514	1,439,243	3,514,757
1902	2,157,127	1,410,603	3,567,730
1903	2,213,580	1,464,672	3,678,252
1904	[b] 2,139,784	1,527,573	3,667,357

[a] Report of the English Industrial Alcohol Committee, 1905.

[b] Decrease mainly due to the fact that certain firms were allowed to denature alcohol by other substances than wood naphtha.

FRANCE.

The general denaturing process followed in France consists in adding to 90 per cent alcohol 10 per cent of wood spirit (methyl alcohol), which contains 25 per cent of acetone and 2.5 per cent of various impurities. If the product is to be used for lighting or heating 0.5 per cent of heavy benzine is added in addition to the general denaturing agent, and when used for "finish" 4 per cent of gum resin is added. There are also special denaturing processes authorized for products or classes of products which can not make use of alcohol containing wood spirit. Examples of such cases are chloroform, for making which the alcohol is denatured by mixing with chlorid of lime in solution, and chloral, for which purpose a current of chlorin gas is past thru the alcohol. Not less than 440 gallons of spirit may be denatured by the general formula and not less than 220 gallons by any special formula.[a]

The average price of denatured alcohol is difficult to establish, inasmuch as the 90 per cent alcohol which serves as a basis varies greatly in price. The denatured product does not sell for less than 11 cents a liter (1.05 quarts) at this time.[b] It must also be remembered that the French Government has done much to encourage the growth of this industry. In June, 1906, a commission of analytical methods in regard to alcohol was named and prizes are offered for the improvement of the denaturing processes and for improved methods of utilizing alcohol for lighting. Since 1901 a bounty on alcohol manufactured in France and submitted to complete denaturation has been paid, which amounts to about 5 cents a gallon. The following table shows the growth in this industry during the past three years and the various purposes for which the denatured alcohol is employed:

TABLE VII.—*Consumption of denatured alcohol in France, 1903–1905, inclusive.*[c]

Purpose for which used.	1905.	1904.	1903.
	Gallons.	*Gallons.*	*Gallons.*
Heating and lighting	8,326,084	7,654,287	6,922,218
Varnishes	305,222	328,443	305,909
Polishes, etc	46,415	47,552	66,095
Plastic materials	562,497	495,874	530,851
Manufacture of hats	6,023	6,287	9,642
Dyeing and colors	14,635	10,329	14,054
Rennet	3,910	2,932	3,751
Collodion	11,016	7,185	3,857
Chloroform	4,914	4,596	9,959
Chloral	10,091	7,978	6,499
Tanning materials	14,978	40,920	21,081
Chemical and pharmaceutical products	178,843	182,410	300,652
Scientific uses	31,515	22,824	13,710
Ethers, fulminates, explosives	2,961,900	2,375,342	1,687,495
Total	12,478,043	11,186,959	9,895,773

[a] Report of the English Industrial Alcohol Committee, 1905.

[b] Department of Commerce and Labor, Bureau of Manufactures, Daily Consular and Trade Reports, August 6, 1906.

[c] Sidersky, Bull. de l'Association des chimistes de sucrerie et de distillerie, November, 1905, p. 545; 1905 figures from Zts. Spiritusind., 1906, *29*, No. 35, 323.

Beets, molasses, grain, and potatoes are the principal sources of industrial alcohol in France, the beets and molasses far exceeding other sources in importance.

GERMANY.

The general denaturing agent authorized in Germany consists of 1 part pyridin (obtained by distillation from coal tar) and 4 parts wood alcohol, to which may be added to each quart approximately 1.7 ounces of lavender oil or rosemary oil. In other words, the German denatured alcohol contains 2 per cent of wood alcohol and 0.5 per cent of pyridin, with optionally 0.125 per cent of lavender or rosemary oil.

Alcohol is completely denatured for use in motor cars, etc., by the use of 1.25 liters (1.32 quarts) of the general denaturing agent, 0.25 liter (0.26 quart) of a solution of methyl violet dye, and 2 to 20 liters (2.11 to 21.13 quarts) of benzol to every hectoliter (26.4 gallons) of alcohol.[a]

There are many formulas for the incomplete denaturing of alcohol to be used for special purposes, of which the following are typical examples:

For industrial uses of all kinds: 5 liters (5.28 quarts) of wood alcohol or 0.5 liter (0.53 quart) of pyridin bases per hectoliter (26.4 gallons) of alcohol.

For various chemical preparations: 10 liters (2.64 gallons) of sulfuric ether, or 1 liter (1.06 quarts) of benzol, or 0.5 liter (0.53 quart) of turpentine, or 0.025 liter (0.026 quart) of animal oil, per 100 liters (26.4 gallons) of alcohol.

For soap making: 1 kilogram (2.2 pounds) of castor oil and 400 cubic centimeters (24.4 cubic inches) of soda solution.

For varnishes and polishes of all kinds: 2 liters (2.11 quarts) of wood spirit and 2 liters of petroleum benzin, or 0.5 liter (0.53 quart) of turpentine.

The following statistics regarding the production of spirits in Germany, the consumption of tax-free alcohol of different classes, and the materials used in its production, have been compiled by the Bureau of Statistics of the Department of Agriculture as showing the present development of the alcohol industry in Germany:[b]

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[a] Report of the English Industrial Alcohol Committee, 1905.

[b] Compiled from Vierteljahrshefte zur Statistik des Deutschen Reichs, 1906.

TABLE VIII.—*Production of spirits in Germany during the industrial years (October 1 to September 30) 1904–5 and 1903–4.*

Distilleries.	1904–1905.		1903–1904.	
	Distilleries in operation.	Alcohol produced.	Distilleries in operation.	Alcohol produced.
		Gallons.		*Gallons.*
Agricultural distilleries:				
Potato	6,048	75,860,933	6,059	80,304,589
Grain	7,620	8,615,719	8,934	7,593,514
Total	13,668	84,476,652	14,993	87,898,103
Industrial distilleries:				
Potato	21	149,864	22	151,158
Grain	780	11,612,490	788	10,699,810
Molasses	29	2,851,715	29	2,452,501
Other materials	39	4,253	39	2,695
Total	869	14,618,322	878	13,306,164
Other distilleries working up nonfarinaceous materials	57,635	958,145	50,160	614,750
Grand total	72,172	100,053,119	66,031	101,819,017

TABLE IX.—*Consumption of tax-free alcohol in the German Empire.*

Industrial year, October 1 to September 30.	Total tax-free alcohol.	Fully denatured.			Partially denatured.
		By the usual method.	By the admixture of benzol.	Total.	
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1904	36,943,805	24,418,052	1,471,004	25,889,056	10,353,615
1903	36,769,690	24,604,952	1,393,867	25,998,819	10,195,535
1902	33,779,735	23,002,206	778,113	23,780,319	9,529,405
1901	29,324,191	.....	.....	18,616,826	9,137,482
1900	30,534,591	.....	.....	20,665,887	8,975,281

Industrial year, October 1 to September 30.	Without denaturation.				
	In public hospitals, etc.	In public scientific institutions.	In military technical institutions.	For making smokeless powder, fusees, and fulminates.	Total.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1904	74,206	53,679	10,752	562,497	701,134
1903	65,937	50,905	3,540	454,954	575,336
1902	58,672	51,566	15,903	343,870	470,011
1901	53,125	51,619	.....	458,995	[a] 1,569,883
1900	48,634	46,890	.....	457,569	[b] 893,423

[a] Of which 1,006,144 gallons were used in the manufacture of medicines.

[b] Of which 340,330 gallons were used in the manufacture of medicines.

TABLE X.—*Materials worked up in distilleries in Germany during the industrial years (October 1 to September 30) 1904–5 and 1903–4.*

Materials.	1904–1905.	1903–1904.
	Tons.	*Tons.*
Potatoes	2,734,443	2,900,461
Rye	126,416	119,510
Barley	186,359	184,323
Corn and dari	121,350	93,319
All other grains and farinaceous stuffs	22,728	21,556
Molasses, beets, and beet juice	45,497	40,027
Other materials	1,182	1,143
Total	3,237,975	3,360,339
	Gallons.	*Gallons.*
Brewery refuse and yeast broth	2,123,742	2,273,474
Seed fruit and pomace	7,167,540	2,317,880
Stone fruit	10,359,400	5,049,372
Fruit and grape wine	871,497	554,651
Wine lees and rapes	16,359,414	14,109,293
Other materials	3,004,881	2,274,847
Total	39,886,474	26,579,517

As is shown in Table X, potatoes are by far the most important source of industrial alcohol in Germany where this crop is cultivated with a special view to its alcohol-producing qualities. The retail price of denatured alcohol (95 per cent by volume) is 29.69 cents a gallon, 90 per cent alcohol costing 27 cents, while gasoline sells for 20.8 cents a gallon and kerosene at 15 cents a gallon.

In comparing the figures for Germany with those for the United States it must be remembered that the German alcohol is 95 per cent commercial strength, and hence the number of gallons given must be almost doubled to compare with the taxable gallons of 50 per cent strength produced in the United States. The total number of taxable gallons produced in the United States during 1905, other than from fruit, was 147,810,794, and from fruit, 5,448,584, making a total of 153,259,378. The figures for Germany show a total of 100,053,119 gallons, or about 200,000,000 United States taxable gallons. Thus the German output, in round numbers, is 50,000,000 taxable gallons greater than that of the United States. With the vast agricultural resources of this country there will be no difficulty in increasing the consumption of industrial alcohol in the United States to equal or exceed that of Germany. This increase, however, must come slowly and probably after many disappointments, both of an agricultural and a technical character.

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The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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O

UTILIZATION OF WASTE MATERIAL OR BY-PRODUCTS.

STALKS OF INDIAN CORN AND SORGHUM.

The stalks of sweet corn, field corn, and sorghum contain large quantities of sugars, and also considerable amounts of starch at the time of the hardening of the starch in the seeds. When sweet corn is harvested for the market its stalk contains considerable quantities of fermentable matter, as has already been stated. Large quantities of this material are grown in the United States every year, and after the harvest of the sweet corn for the market the stalks are utilized chiefly for fodder. In the curing of the stalks for fodder the sugars ferment and disappear. If these stalks could be used economically they would add largely to the raw materials from which alcohol could be made. The technical difficulties, however, attending the utilization of the stalks are so great that it is doubtful whether means can be devised whereby their use may be made profitable for alcohol making. Notwithstanding this, it is a matter which is well worthy of investigation, because if stalks of sweet corn and field corn could be utilized they would place at the disposal of the manufacturer an almost inexhaustible source of raw material from which alcohol might be made. At the present time, however, there is no immediate probability of the economic utilization of this material.

The stalks of sorghum, as is well known, contain very large quantities of fermentable matter at the time of ripening. All of these bodies—that is, the stalks of sweet corn, field corn, and sorghum—contain, in addition to the sugar, notable quantities of starch and gum, which after conversion into a sugar, by malt or otherwise, add greatly to their value for alcohol making. In so far as the question of raw materials is concerned there are no other sources available in the United States so abundant as those found in sweet corn, field corn, and sorghum stalks.

The great difficulty encountered in connection with the utilization of these materials is that the season in which these stalks are suitable for utilization in the manufacture of alcohol is very limited. For instance, in the vicinity of Washington none of these stalks would be available until the latter part of July, and their availability would not continue later than the middle or the end of October under the most favorable circumstances. This gives at most a manufacturing period of only two or three months. The cost of preserving the stalks for a longer period would probably be so great under present conditions as to preclude the possibility of the remunerative manufacture of alcohol therefrom. In consideration, however, of the tremendous extent of this source of supply, it seems advisable that those in charge of the agricultural experiment stations and

other experimental investigators throughout the country should study the possibilities of manufacturing industrial alcohol at remunerative rates, at least during a part of the year, from these waste products of the maize crop.

MOLASSES.

The utilization of the waste materials from the sugar factories and sugar refineries for the purpose of making alcohol is a well-established industry. The use of these sources of supply depends, of course, upon the cost of the molasses. When the sugar has been exhausted as fully as possible from the molasses the latter consists of a saccharin product, containing considerable quantities of unfermentable carbohydrate matter, large quantities of mineral salts, and water. In molasses of this kind there is probably not more than 50 pounds of fermentable matter to 100 pounds of the product. Assuming that a gallon of such molasses weighs 11 pounds, it is seen that it contains 5½ pounds of fermentable matter, yielding 2¼ pounds of industrial alcohol of 95 per cent strength. It requires about 3 gallons of such molasses to make 1 gallon of industrial alcohol. The quantity of molasses made in the United States as a residual product from the sugar manufacture is difficult to determine. For each ton (2,240 pounds) of sugar produced we may assume that there are 62½ gallons of molasses. Placing the total output of sugar in the United States at 400,000 tons, beet and cane combined, would give a yield of molasses of 25,000,000 gallons.

The quantity of molasses produced in Cuba is three or four times as great as that produced in the United States, thus affording a very extensive source of production of industrial alcohol should it prove profitable to make it from this material. The above data show that when the price of molasses delivered to the refineries falls as low as 5 or 6 cents a gallon it may be considered a profitable source of alcohol.

In 1905, 13,500,000 gallons of alcohol were produced in France from beet-root molasses. The production from this source is decreasing—in 1901 almost double the above amount was made.

WOOD PULP AND SAWDUST.

Many attempts have been made to produce alcohol for industrial purposes from sawdust, wood pulp, or waste wood material. The principle of the process rests upon the fact that the woody substance is composed of cellulose and kindred matters which, under the action of dilute acid (preferably sulphuric or sulphurous) and heat, with or without pressure, undergo hydrolysis and are changed into sugars. A large part of the sugar which is formed is nonfermentable, con-

sisting of a substance known as xylose. Another part of the sugar produced is dextrose, made from the true cellulose which the wood contains.

The yield of alcohol in many of the experiments which have been made has not been very satisfactory. It is claimed, however, by some authors that paying quantities of alcohol are secured. In Simmonsen's process for the manufacture of alcohol one-half per cent sulphuric acid is employed and from four to five parts of the liquid heated with one part of the finely comminuted wood for a quarter of an hour under a pressure of nine atmospheres. It is claimed by Simmonsen that he obtained a yield of 6 quarts of alcohol from 110 pounds of air-dried shavings. Another process which has been tried in this and other countries for converting comminuted wood into alcohol is known as Classen's. The comminuted wood is heated for fifteen minutes in a closed apparatus at a temperature of from 248° to 293° F. in the presence of sulphurous acid (fumes of burning sulphur) instead of sulphuric acid. It is claimed by the inventor that he has made as much as 12 quarts of alcohol from 110 pounds of the air-dried shavings. There is reason to doubt the possibility of securing such high yields in actual practice as are claimed in the above processes. That alcohol can be made from sawdust and wood shavings is undoubtedly true, but whether or not it can be made profitably must be determined by actual manufacturing operations.

WASTE PRODUCTS OF CANNERIES, ETC.

There are a great many waste products in the fruit industry, as well as in the canning industry, which contain sugar and starch, and it has been proposed to use these for the manufacture of alcohol. It is true that all waste products which contain sugar or starch may be used for alcohol-making purposes, but it is doubtful if many of them will be found of a character which will permit their use in competition with other materials containing larger quantities of fermentable matter. The principal waste materials which may be considered in this connection are the refuse of wine making, fruit evaporating, and canning industries, especially the waste of factories devoted to the canning of tomatoes and Indian corn. In addition to this, the waste fruit products themselves, which are not utilized at all, as, for instance, the imperfect and rotten apples, tomatoes, grapes, etc., may be favorably considered. The quantity of waste products varies greatly in different materials.

The quantities of waste material in grapes and apples, as shown by Lazenby, are as follows: About 25 per cent of the total weight in grapes, with the exception of the wild grape, where it is about 60 per

cent; with apples the average percentage of waste was found to be 23.8 per cent from twenty-five varieties. This included the waste in the core, skin, and the defective apples caused by insects, fungi, bruises, etc. In general it may be said that in the preparation of fruits for preserving purposes about 25 per cent of their weight is waste, and this, it is evident, could be utilized for the manufacture of alcohol. If apples be taken as a type of fruits, we may assume that the waste portions contain 10 per cent of fermentable matters, which, however, is perhaps rather a high estimate. Five per cent of this might be recovered as industrial alcohol. Thus, each 100 pounds of fruit waste in the most favorable circumstances might be expected to

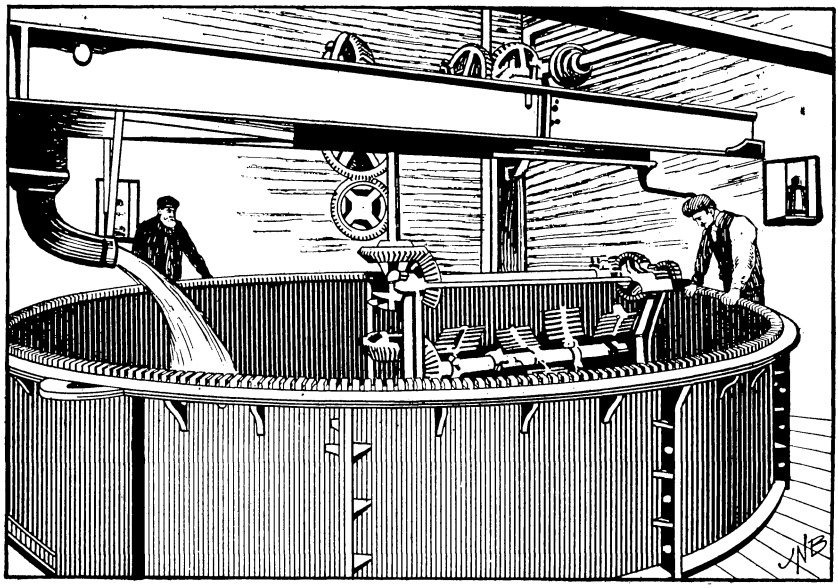

FIG. 3.—Mash tun in an Irish distillery.

produce 5 pounds of industrial alcohol. The quantity of waste which could be utilized for this purpose would hardly render it profitable to engage in the manufacture. A smaller percentage could be expected from the waste of the tomato, where the quantity of sugar is not so great. In the waste of the sweet-corn factory the amount of fermentable matter would depend largely on the care with which the grain was removed. There is usually a considerable quantity of starchy material left on the cobs, and this, with the natural sugars which the grown cobs contain, might yield quite large quantities of fermentable matter. It would not be profitable to erect distilleries simply for the utilization of waste of this kind, but if these wastes could be utilized in distilleries already established it might be profitable to devote them to this purpose.

MANUFACTURE OF ALCOHOL.

The three principal steps in the manufacture of alcohol are (1) the preparation of the mash or wort, (2) the fermentation of the mash or wort drawn off from the mash tun, and (3) the distillation of the dilute alcohol formed in the beer or wash from the fermentation tanks. The preparation of the mash includes (1) the treatment of the material used with hot water to form a paste of the starch or the sugar, and (2) the action of the malt or ferment on the paste to convert the starch into fermentable sugar.

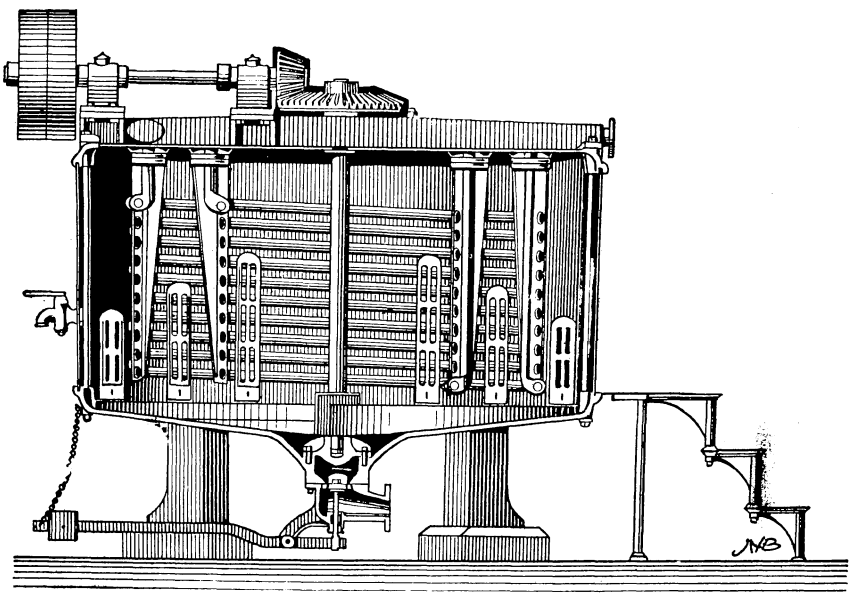

FIG. 4.—Mashing and cooling apparatus, cross section.

MASHING.

Figs. 3 and 4 show two views of the mashing tun or tank, the first figure giving the general appearance, and the second a view of the interior of the tun, showing the machinery by which the stirring is effected and the series of pipes for cooling the finished product down to the proper temperature for the application of the malt.

The object of the mash tun is to reduce the starch in the ground grain to a pasty, gummy mass, in order that the ferment of the malt may act upon it vigorously and convert it into sugar. If the mashing be done before the addition of the malt the temperature may be raised to that of boiling water. If, however, the malt be added before the mashing begins, the temperature should not rise much, if any, above 140° F., since the fermenting power is retarded and disturbed at

higher temperatures. The mashing is simply a mechanical process by means of which the starch is reduced to a form of paste and the temperature maintained at that point which is best suited to the conversion of the starch into sugar.

FERMENTATION.

Fermenting tanks.—The mash, after the starch has all been converted into sugar, goes into fermenting tanks, which in Scotland are called "wash backs," when the yeast is added. A view of the typical wash back is shown in fig. 5. They often have a stirring apparatus, as indicated in the figure, whereby the contents can be thoroughly mixed

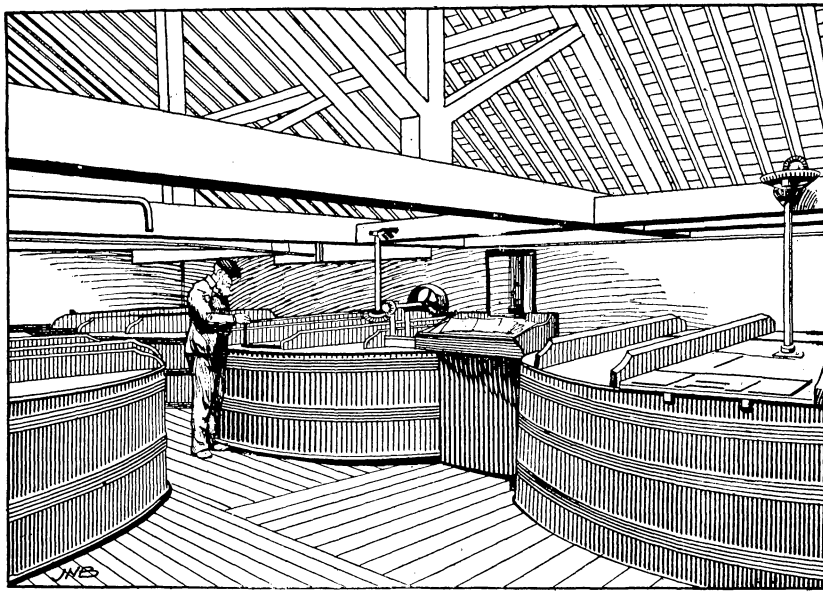

FIG. 5.—Fermentation tanks in an Irish distillery.

with the yeast and kept in motion. This is not necessary after the fermentation is once well established, but it is advisable, especially in the early stages, to keep the yeast well distributed throughout the mass. In these tanks the fermentations are conducted, the temperature being varied according to the nature of the product to be made. For industrial alcohol the sole purpose should be to secure the largest possible percentage of alcohol without reference to its palatable properties.

Action of yeast.—It is unnecessary to go into detailed discussion of the process of fermentation, meaning by that the ordinary alcoholic fermentation. An organism belonging to the vegetable family and to which the name "yeast" has been given is the active agent

in fermentation. The organism itself does not take a direct part in the process, but it secretes another ferment of an unorganized character known as an "enzym" or a "diastase." This enzym has the property, under proper conditions of food, temperature, and dilution, of acting upon sugar and converting it into alcohol and carbonic acid. Anyone who has ever seen a fermenting vat in full operation and noticed the violent boiling or ebullition of the liquor, can understand how rapidly the gas "carbon dioxid" or "carbonic acid," as it is usually called, may be formed, as it is the escape of this gas which gives the appearance to the tank of being in a violent state of ebullition. The yeast which produces the fermentation belongs to the same general family as the ordinary yeast which is used in the leavening of bread. The leavening of bread under the action of yeast is due to the conversion of the sugar in the dough into alcohol and carbon dioxid or carbonic acid. The gas thus formed becomes entangled in the particles of the gluten, and these expanding cause the whole mass to swell or "rise," as it is commonly expressed. Starch can not be directly fermented, but must be first converted into sugar, either by the action of a chemical like an acid, or a ferment or enzym, known as diastase, which is one of the abundant constituents of malt, especially of barley malt. In the preparation of a cereal, for instance, for fermentation, it is properly softened and ground, and then usually heated with water to the boiling point or above in order that the starch may be diffused throughout the water. After cooling it is treated with barley malt, the diastase of which acts vigorously upon the starch, converting it into a form of sugar, namely, maltose, which lends itself readily to the activities of the yeast fermentation. (See figs. 6–8.)

When ordinary sugar (cane sugar, beet sugar, and sucrose) is subjected to fermentation it is necessary that the yeast, which also exerts an activity similar to that of malt, should first convert the cane sugar into invert sugar (equal mixtures of dextrose and levulose)[a] before the alcoholic fermentation is set up. The cane sugar is also easily inverted by heating with an acid.

Temperature and materials.—When different kinds of sugars and starches are fermented for the purpose of making a beverage it is important that the temperature of fermentation be carefully controlled, since the character of the product depends largely upon the temperature at which the fermentation takes place. On the contrary, when industrial alcohol is made the sole object is to get as large a yield as possible, and for this reason that temperature should be employed which produces the most alcohol and the least by-products, irrespective of the flavor or character of the product made.

[a] See page 13 for explanation of term "invert sugar."

Also, in the making of alcoholic beverages, it is important that the malt be of the very best quality in order that the resulting product may have the proper flavor. In the production of alcohol for industrial purposes this is of no consequence, and the sole purpose here should be to produce the largest possible yield. For this reason there is no objection to the use of acids for converting the starch, cane sugar, and cellulose into fermentable sugars. Therefore, the heating of the raw materials under pressure with dilute acids in order to procure the largest quantity of sugar is a perfectly legiti-

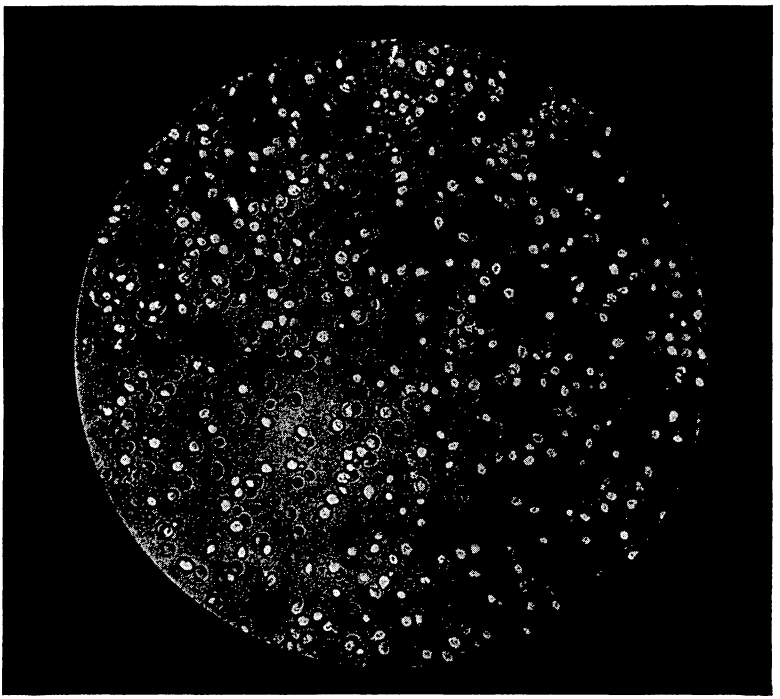

FIG. 6.—Photomicrograph of brewer's yeast (× 250).

mate method of procedure in the manufacture of industrial alcohols.

Sugars and starches are usually associated in nature with another variety of carbohydrates known as cellulose, and this cellulose itself, when acted upon by an acid, is converted very largely into sugars, which, on fermentation, yield alcohol. For industrial purposes, the alcohol produced in this manner is just as valuable as that made from sugar and starch. Whether the diastatic method of converting the starch and sugar into fermentable sugars be used, or the acid method, is simply a question of economy and yield. Whichever method gives the largest quantity of alcohol at the smallest expense

is certain to come into general use. On the other hand, when alcoholic beverages are to be made, those processes must be employed, irrespective of the magnitude of the yield, which give the finest and best flavors to the products.

DISTILLATION.

The object of distillation is to separate the alcohol which has been formed from the nonvolatile substances with which it is mixed. A typical form of distilling apparatus for the concentration of the dilute

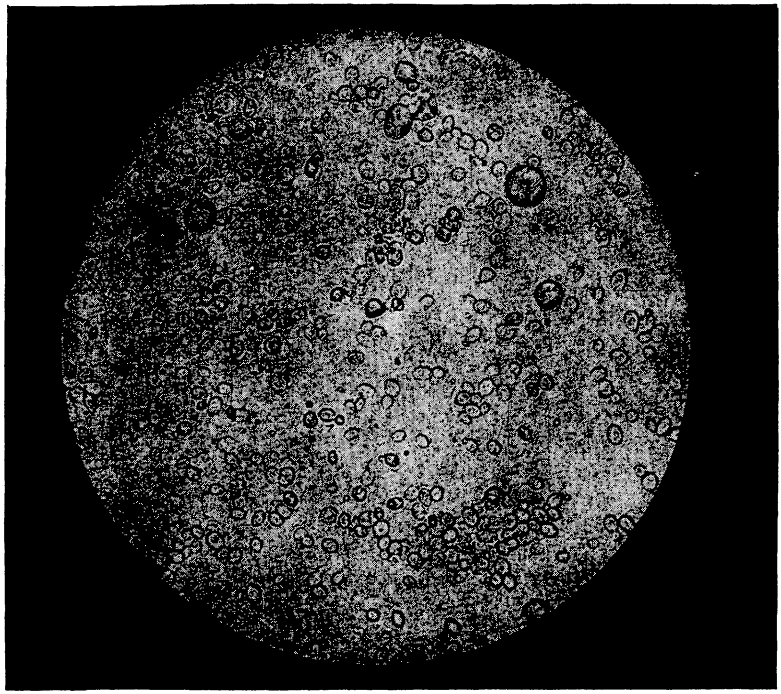

FIG. 7.—Photomicrograph of household yeast; large grains are starch (× 250).

alcohol, which is formed in the beer or wash from the fermentation tanks, is represented in fig. 9.

This apparatus is of the continuous type common to Europe and America. It consists of a "beer still" provided with a number of chambers fitted with perforated plates and suitable overflow pipes. It is operated as follows:

The sirup and alcohol are pumped into the top of the beer still through a pipe G; the tank G may also be placed above the center of the still and the contents allowed to flow into the still by gravity; steam is admitted through an open pipe into the kettle A at the bottom of the column or is produced by heating the spent liquor by means of a coil. The steam ascends through the perforations in the plates, becoming richer and richer in alcohol as it passes through

each layer of liquor, while the latter gradually descends by means of the overflow pipes to the bottom of the column *B* and finally reaches the kettle completely exhausted of alcohol, whence it is removed by means of a pump connected with the pipe line *H*. On reaching the top of the beer still *B* the vapors of the alcohol and the steam continue to rise and pass into the alcohol column *C*. This column is also divided into chambers, but by solid instead of perforated plates, as shown at *K*. Each chamber is provided with a return or overflow pipe and an opening through which the vapors ascend. In the alcohol column the vapors are so directed as to pass through a layer of liquid more or less rich in alcohol which is retained by the plate separating the compartments. An excess of liquids in these compartments overflows through the down pipes, gradually works its way into the beer still, and thence to the kettle. On reaching the top of the column the vapors, which have now become quite rich in alcohol, are passed into a coil provided with an outlet at the lowest part of each bend. These outlets lead into the return pipe *P*, which connects with the top chamber of the alcohol column. This coil is technically termed the "goose" and is immersed in a tank called the "goose tub." A suitable arrangement is provided for controlling the temperature of the water in the tub by means of outlet and inlet water pipes. When the still is in operation the temperature of the "goose" is regulated according to the required density of the alcohol. The object of the "goose" is the return to the column of all low products which condense at a temperature below the boiling point of ethyl alcohol of the desired strength. On leaving the "goose" the vapors enter a condenser *E*, whence the liquid alcohol is conducted into a separator *F*. This separator consists simply of a glass box provided with a cylinder through which a current of alcohol is constantly flowing. An alcohol spindle is inserted in this cylinder and shows the density of the spirit at all times. A pipe, with a funnel-shaped opening at its upper extremity, connects with the pipe leading from the condenser and gives vent to any objectionable fumes. The separator is connected by means of a pipe with the alcohol storage tank. The pipe *O* is for emptying the upper chambers when necessary. The valves *N*, communicating by means of a small pipe with a condenser *M*, are for testing the vapors in the lower chambers for alcohol.

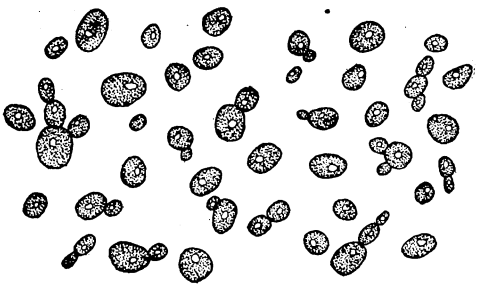

FIG. 8.—Yeast from beer sediment showing budding (× 1270).

Another form of distilling apparatus operated on much the same principle as the one just described is shown in fig. 10.[a]

CONCLUSIONS.

From the preceding discussion the farmer will be readily able to determine the actual value of the raw products he produces for alcohol-manufacturing purposes. The manufacture of alcohol on a very small scale is not likely to prove profitable. Experience has shown that attempts to manufacture sugar and other substances of a similar character on a small scale can not compete with similar manufacturing industries on a large scale, and the regulation requiring that the

[a] For detailed description of this apparatus see Brannt, Distillation and Rectification, p. 214.

alcohol be 180 proof, as before mentioned, will make it difficult, if not impracticable, in the majority of cases for the farmer to produce industrial alcohol on a small scale. A cooperative distillery might, however, be profitably conducted in farming communities.

The still must be constructed as prescribed by law and the process conducted in all its details according to the regulations of the internal revenue, with such exceptions as are noted in the revised regulations of July 15, 1907.[a] It is evident that in most cases the farmer must be content with producing the raw materials and that he can not look forward to becoming a practical distiller. The distilling interests, on the other hand, will have an industry quite distinct and apart from the agricultural interests producing the raw materials.

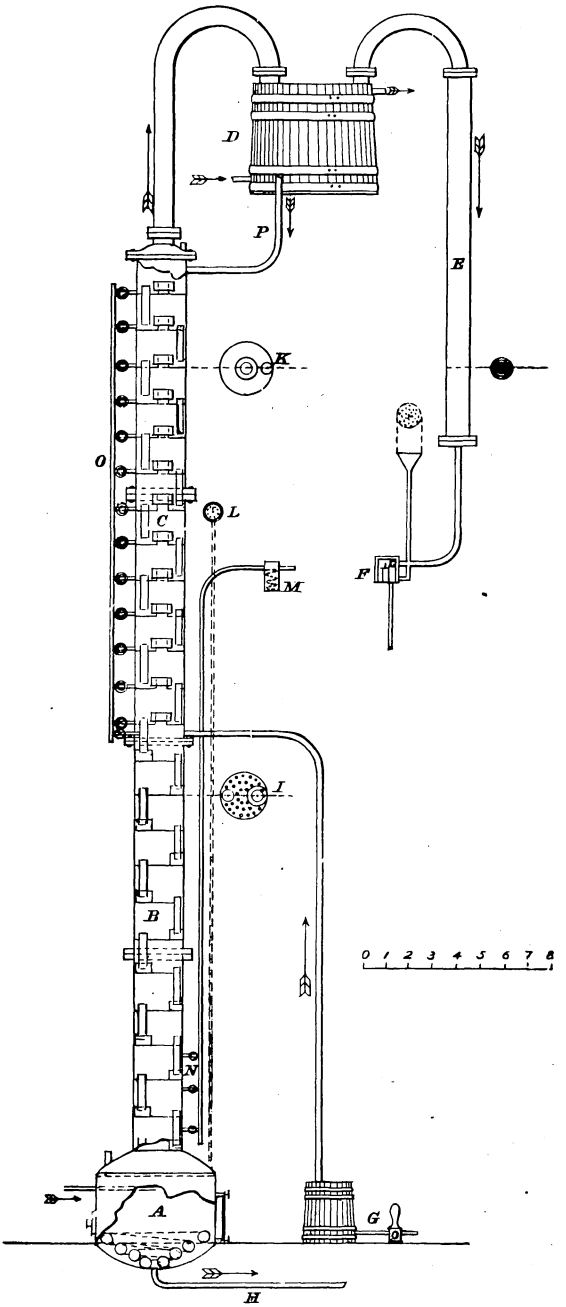

FIG. 9.—Continuous distilling apparatus.

[a] U. S. Internal Revenue, Regulations and Instructions concerning the Tax on Distilled Spirits, etc., No. 7, Revised April 15, 1901; Regulations No. 30, Revised; U. S. Internal Revenue, Regulations and Instructions Concerning Denatured Alcohol, under the act of Congress of June 7, 1906, and amendatory act of March 2, 1907. July 15, 1907.

The principal uses of industrial alcohol are illumination, heating, motive power, and the manufacture of lacquers, varnishes, smokeless powder, medicinal and pharmaceutical preparations, vinegar, ether, etc. Our farmers are chiefly interested in these matters as they refer to illumination, heating, and motive power. When industrial alcohol is made at a price at which it can compete with petroleum and gasoline, it will doubtless be preferred for the purposes above mentioned because of its greater safety and more pleasant odor.

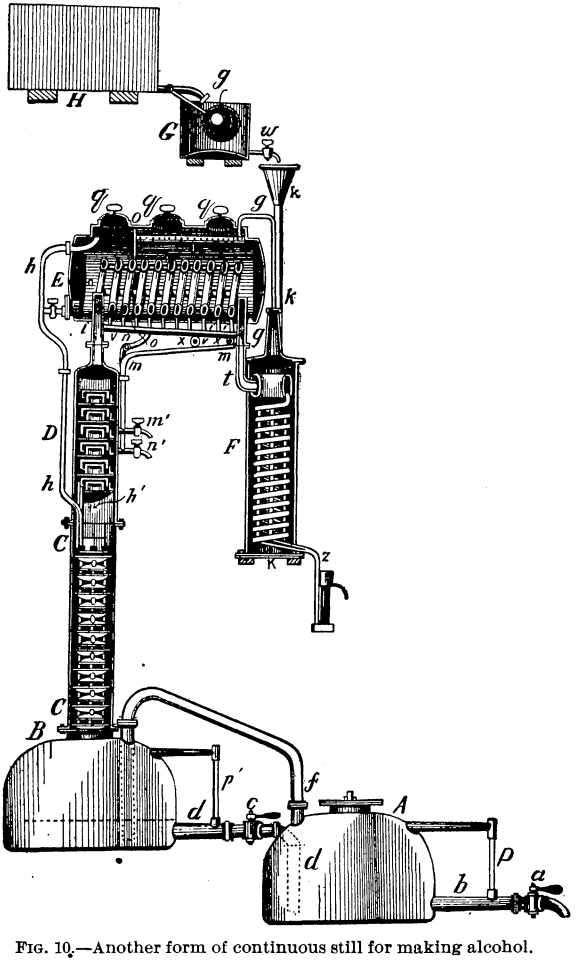

FIG. 10.—Another form of continuous still for making alcohol.

Under the present conditions it is not probable that industrial alcohol can be offered upon the market at much less than 40 cents per gallon of 95 per cent strength. It is believed, however, that by paying attention to unused sources of raw materials and increased production thereof, with improved methods of manufacture and denaturing,

the price can be very much diminished. As the price falls the quantities used for industrial purposes will correspondingly increase, so that small profits both to the farmer and to the manufacturer will bring large returns by reason of the greater quantities of the materials handled.

The benefits which are to accrue from the use of industrial alcohol free of tax have probably been overestimated by the people at large, and especially by the farmers, but that material benefits will accrue is not a subject of doubt. These benefits will come, not suddenly, but slowly, as agricultural products are more abundant, technical methods of manufacture improved, and the methods of utilizing the industrial alcohol better understood. Our people should not, however, be disappointed should many years elapse before the magnitude of the product used for industrial purposes reaches the figure already attained by Germany and some of the other European nations.

Of the raw materials which can be utilized for the manufacture of alcohol, Indian corn is by far the most abundant and the most promising source at the present time. The average price of potatoes must be very much decreased before raw material of this kind can come into competition with Indian corn as a source of alcohol. Promising sources which are not now utilized for the manufacture of alcohol in this country are the potato, the sweet potato, the yam, sorghum, molasses from the cane-sugar and beet-sugar factories, and the Indian-corn stalk. Waste materials of other manufacturing industries, such as those related to fruits and vegetables, may incidentally be utilized for manufacturing purposes, but could not of themselves become independent sources of profitable industrial alcohol.

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FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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